Reoperation for recurrent chronic visceral ischemia

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Purpose: **Recurrent visceral ischemia after a failed visceral revascularization occurs in up to one third of patients, yet no comprehensive report has described the management of this problem. The purpose of this study was to examine the presentation, surgical management, and outcome of patients with recurrent visceral ischemia.**

Methods: **Between 1959 and 1997, 109 patients underwent primary visceral revascularization at the University of California, San Francisco. Nineteen patients (17.4%) had recurrent visceral ischemia (12 chronic visceral ischemia, seven acute visceral ischemia). Fourteen additional patients with recurrent chronic visceral ischemia were referred after failed primary revascularization (two patients underwent multiple operations before referral). Thirty visceral reoperations were performed for recurrent visceral ischemia in 24 patients (10 patients with recurrence at University of California, San Francisco, 14 referred patients). Symptom-free and overall survival rates were determined by life table analysis.**

Results: **Of seven patients (6.4%) who had recurrent acute visceral ischemia, six (85.7%) died of bowel infarction. Twelve patients (11%) had recurrent chronic visceral ischemia. Patients with recurrent chronic visceral ischemia received their diagnoses earlier and lost less weight than at their initial presentation (p = 0.004 and 0.001, respectively). Recurrent ischemia was associated with younger age, greater weight loss, and modification of surgical technique at the time of initial operation (p = 0.5, 0.009, and 0.02, respectively). For 20 (90.9%) of the 22 first reoperations, antegrade aortovisceral bypass (n = 10) or transaortic visceral endarterectomy (n = 10) was used. Multiple techniques (four antegrade bypass, two retrograde bypass, one endarterectomy, one anastomotic revision) were used in the eight second or third reoperations. Postoperative mortality and complication rates were 6.7% and 33.3%, respectively. Symptoms recurred in six of 22 patients (27.3%) after the first reoperation, three of whom were cured or improved after additional reoperations. The life table symptom-free survival rate after reoperation was 77.3% and 62.8% at 1 and 5 years, respectively. The life table overall survival rate after reoperation was 74.6% at 5 years.**

Conclusions: **Recurrent visceral ischemia is not uncommon after primary visceral revascularization. These results show that reoperation for recurrent chronic visceral ischemia can be accomplished safely and effectively with established revascularization techniques. Furthermore, after repeat visceral revascularization patients achieve durable relief of symptoms and have life expectancy rates comparable with those of patients who undergo primary visceral revascularization. (J Vasc Surg 1998;27:276-86.)**

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Since Shaw and Maynard[1] described the first successful operative correction of chronic visceral ischemia in 1958, surgical techniques of visceral revascularization have evolved that have a low operative mortality rate and achieve durable relief of symptoms.[2-6] In our experience over three decades, transaortic visceral endarterectomy and antegrade aortovisceral bypass are the preferred revascularization techniques. More than 85% of patients remained cured or improved at 5 years.[2] In addition,

Table I. Patients who underwent visceral revascularization

	Patients	*Reoperations*
No recurrence	90	—
Recurrent chronic visceral ischemia		
Primary revascularization at UCSF	12	14
Primary revascularization elsewhere	14	16
Recurrent acute visceral ischemia		
Primary revascularization at UCSF	7	(2)*
Total	123	30

*Both patients with acute recurrence underwent graft thrombectomy only.

Table II. Operations for chronic visceral ischemia at UCSF

	No.
Primary revascularization	109
Secondary revascularization	
First reoperation	22
Second reoperation	5
Third reoperation	3
Total visceral operations	139

others have documented a 3-year 89% cumulative patency rate of aortovisceral bypass grafts with objective follow-up with duplex scanning or arteriography.[3]

Although primary visceral revascularization is successful in most patients, all methods of operative revascularization are susceptible to late failures. Recurrent visceral ischemia has been reported in up to one third of patients who undergo visceral revascularization.[6-8] Although strategies for the management of this problem have been suggested,[9,10] no report to date has described the clinical presentation and management of recurrent visceral ischemia in a substantial series of patients. In this report we review our experience with the clinical presentation, surgical treatment, and outcome of patients with recurrent visceral ischemia after primary visceral revascularization.

PATIENTS AND METHODS

The records of 123 patients who underwent visceral revascularization at the University of California, San Francisco (UCSF) from January 1959 through April 1997 were reviewed. Patients were identified from a prospectively acquired database of all vascular surgery procedures performed at UCSF. All patients included in this study had symptoms consistent with chronic visceral ischemia and underwent either primary visceral revascularization, reoperation for recurrent visceral ischemia, or both at UCSF. Specifically excluded were patients who were undergoing revascularization for visceral artery disease of nonatherosclerotic cause including arcuate ligament syndrome, coarctation, vasculitis, aortic dissection, and mesenteric embolectomy alone without additional reconstruction. Records of primary or secondary visceral artery operations conducted at other institutions before referral were obtained. Follow-up data were collected from hospital and clinic charts and by telephone interview of the patients, their families, or referring physicians.

Patients who underwent visceral revascularization at UCSF and the visceral operations performed are summarized in Tables I and II. Of the 109 patients who underwent primary visceral artery revascularization, durable relief of ischemic symptoms was achieved in 90 patients. In 19 patients (17.4%) symptomatic recurrent visceral ischemia developed. Ten patients (9.2%) had recurrent chronic visceral ischemia and underwent secondary visceral revascularization. Two additional patients (1.8%) had recurrent chronic visceral ischemia but did not undergo a second revascularization procedure. Seven patients (6.4%) had acute visceral ischemia and bowel infarction. An additional 14 patients underwent operations for chronic visceral ischemia at other institutions and were referred for treatment of recurrent chronic visceral ischemia. Before referral one of these 14 patients underwent two visceral operations, and the other underwent three visceral operations.

A total of 30 visceral reoperations were performed in 24 patients with recurrent chronic visceral ischemia. Fourteen reoperations were performed in 10 patients who had their original revascularization at UCSF, and 16 reoperations were performed in 14 patients who had their original visceral revascularization elsewhere. The 30 visceral reoperations included first (n = 22), second (n = 5), or third (n = 3) reoperations after failed primary or secondary visceral operations (Table II). Antegrade aortovisceral bypass grafting or transaortic visceral thromboendarterectomy, the procedures of choice for chronic visceral ischemia at UCSF, were used for most visceral reoperations. These techniques have been described in detail.[2,11,12]

To identify factors associated with recurrent visceral ischemia among the 109 patients who underwent primary visceral revascularization at UCSF, the 90 patients who underwent primary visceral revascu-

Table III. Profile of patients who underwent reoperation (n = 24)

	No.	*%*
Age at primary operation (yr)	57.3 ± 8.2	
Age at first reoperation (yr)	60.2 ± 9.1	
Sex		
Women	21	87.5
Men	3	12.5
Ratio (female/male)	7:1	
Risk factors		
Diabetes	0	0.0
Smoking	18	75.0
Pack-years	43.0 ± 22.8	
Hypertension	14	58.3
Associated illnesses		
Peripheral vascular	12	50.0
Cardiac	5	20.8
Renal	1	4.2
Serum creatinine (mg/dl)	0.8 ± 0.2	
Pulmonary	1	4.2
Previous surgery		
Peripheral vascular	9	37.5
Gastrointestinal tract	11	45.8
Gastrointestinal tract for ischemia/infarction	3	12.5
No. vessels revascularized at primary operation		
1 visceral artery	13	54.2
2 visceral arteries	11	45.8
3 visceral arteries	0	0.0
Mean	1.5 ± 0.5	

Table IV. Clinical presentation at first reoperation (n = 22)

	No.	*%*
Symptoms		
Symptomatic interval (mo)		
At primary operation	11.7±9.8	
At reoperation*	3.0±2.9	
Abdominal pain pattern		
Postprandial	18	81.8
Atypical	4	18.2
None	0	0.0
Other gastrointestinal symptoms	17	77.3
Physical findings		
Abdominal bruit	16	72.7
Abnormal peripheral pulses	11	50.0
Weight loss		
At primary operation	18	81.8
Mean (lbs)	29.1±16.6	
At reoperation	10	45.5
Mean (lbs)†	9.9±8.4	
Preoperative aortography		
Visceral arteries involved		
Celiac/IMA	1	4.5
SMA/IMA	1	4.5
Celiac/SMA	8	36.4
Celiac/SMA/IMA	12	54.5
Average number of diseased viscerals	2.5±0.5	
Renal arteries involved	8	36.4

*$p = 0.004$ (unpaired t test).
†$p = 0.001$ (unpaired t test).

larization at UCSF and did not have recurrent visceral ischemia were compared with the 19 patients who underwent primary visceral revascularization at UCSF and had recurrent visceral ischemia (acute or chronic). Groups were compared for differences in risk factors, clinical presentation, operative details, and postoperative complications at primary revascularization.

Data were analyzed with the unpaired t test, Mann-Whitney Rank Sum Test, χ contingency analysis, and Fisher's exact test (one-tailed) where appropriate.[13] Follow-up data were analyzed in life table format, and survival curves were generated with the Kaplan-Meier method.[14] All data are presented as the mean ± SD.

RESULTS

Recurrent chronic visceral ischemia. The clinical profile of 24 patients who underwent reoperation at UCSF for recurrent chronic visceral ischemia (Table III) was similar to that described for patients who underwent primary chronic visceral ischemia.[15] Most patients were female (87.5%), with a female/male ratio of 7:1. The mean age at primary operation was 57.3 years and at first reoperation was 60.2 years. Tobacco use (75%) and hypertension (58.3%) were also prevalent among patients. Nonvisceral vascular disease (50%) and cardiac disease (20.8%) were the most frequently associated conditions, and 37.5% of patients had previously undergone a peripheral vascular operation. Three patients underwent resection of ischemic bowel before reoperation for recurrent visceral ischemia. None of the patients who underwent reoperation had undergone revascularization of all three visceral vessels at their original operation, and more than half (54.2%) had only one visceral artery that underwent revascularization.

Twenty-two of the 24 patients with recurrent chronic visceral ischemia underwent their first visceral reoperation at UCSF; 10 had undergone primary visceral revascularization at UCSF, and 12 were patients referred from other institutions. All patients had abdominal pain that most often was postprandial (81.8%). Pain and weight loss recurred 1.5 months to 26 years (mean, 35.0 ± 54.2 months) after the original operation. The interval from the onset of ischemic symptoms to operation was short-

Table V. Operative details: reoperations for recurrent chronic visceral ischemia

	First reoperation (n = 22)		*Second reoperation (n = 5)*		*Third reoperation (n = 3)*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Visceral technique*						
Antegrade bypass	10	45	2	40	2	67
Transaortic endarterectomy	10	45	1	20	0	0
Other†	2	9	2	40	1	33
Arteries repaired						
Celiac	15	68	2	40	2	67
SMA	12	55	3	60	2	67
IMA	9	41	3	60	1	33
Mean number of repaired arteries	1.6 ± 0.7		1.6 ± 0.5		1.7 ± 1.1	

*Classified according to technique used for celiac and/or SMA if different from technique used for IMA.
†IMA bypass only (n = 2), retrograde SMA bypass (n = 2), thombectomy and anastomotic dilatation (n = 1).

er at reoperation (3.0 ± 2.9 months) than at original operation (11.7 ± 9.8 months; $p = 0.004$). Preoperative weight loss was also less at reoperation (9.9 ± 8.4 pounds) than at original operation (29.1 ± 16.6 pounds; $p = 0.001$; Table IV).

Among the 22 patients undergoing their first visceral reoperation, 20 (90.9%) had disease involving both the celiac axis and the superior mesenteric artery (SMA), and 12 patients (54.5%) had disease involving the celiac, SMA, and inferior mesenteric artery (IMA). The average number of diseased visceral arteries per patient was 2.5 ± 0.5 (Table IV).

Two patients with symptoms of recurrent chronic visceral ischemia did not undergo repeat revascularization. One patient had postprandial pain 6 months after antegrade aortoceliac bypass grafting and transarterial endarterectomy of the SMA. By aortography the celiac bypass had a 50% stenosis, and the SMA was occluded. Nonetheless, her symptoms resolved 3 months later, and the patient was alive 20 years later at last follow-up. One patient receiving renal dialysis was advised by her primary physician (without vascular consultation) that no therapy was available and died after dialysis was electively withdrawn.

Recurrent acute visceral ischemia. Seven of the 19 patients with recurrent visceral ischemia after primary visceral revascularization at UCSF had acute visceral ischemia; three patients had acute ischemia in the perioperative period after the original procedure, and four patients had acute ischemia 8 months to 8 years after the original operation. Six (85.7%) of the seven patients who had acute visceral ischemia subsequently died of intestinal gangrene; two underwent thrombectomy of an occluded aortovisceral bypass grafts and died, two underwent bowel resection and died, and two had extensive bowel infarction and died. The lone survivor had acute abdominal pain 4 months after undergoing antegrade prosthetic bypass to the celiac and SMA. Despite a patent aortovisceral bypass graft, exploratory laparotomy revealed a segment of infarcted jejunum, which was resected successfully. The patient had no symptoms for the next 5 years and then had a fatal stroke. It is interesting that two of the patients who had recurrent acute ischemia had hypercoaguable conditions and thrombosis of bypass grafts: lupus anticoagulant in one patient and heparin-induced thrombocytopenia in the other.

Reoperative techniques. The 30 visceral artery reoperations performed in 24 patients with recurrent chronic visceral ischemia are summarized in Table V. Of the 30 procedures, 22 were first reoperations, five were second reoperations, and three were third reoperations. Visceral revascularization procedures included antegrade aortovisceral bypass (n = 14) and transaortic visceral endarterectomy (n = 11). Other techniques were used in the remaining five cases (Table V). The mean number of visceral arteries that underwent revascularization at first (1.6 ± 0.7), second (1.6 ± 0.5), or third (1.7 ± 1.1) reoperation did not vary. Nineteen celiac arteries, 17 SMAs, and 13 IMAs were repaired.

Of the 22 patients undergoing their first reoperation, 20 were treated with transaortic visceral endarterectomy (n = 10) or antegrade aortovisceral bypass (n = 10). Moreover, the type of revascularization technique (endarterectomy or bypass) selected for first reoperation was based on the technique used at the original revascularization procedure. When the technique used at the original procedure was bypass (n = 13), transaortic endarterectomy was used at first reoperation in nine (69.2%) patients. Conversely, when the tech-

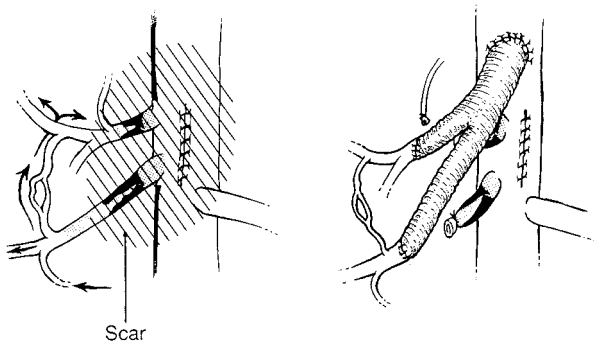

Fig. 1. Conversion of failed visceral endarterectomy to antegrade aortovisceral bypass. **A,** Recurrent stenosis of celiac artery and occlusion of SMA after transaortic endarterectomy. Note overlying scar and blood supply from collateral sources (*arrows*). **B,** Revascularization with bifurcated Dacron graft anastomosed end–to–end to celiac and SMA. Note proximal anastomosis to supraceliac aorta above scar.

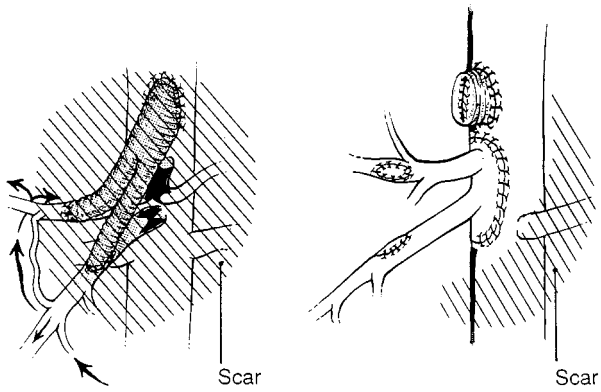

Fig. 2. Revascularization after failed antegrade aortovisceral bypass with distal end–to–side anastomosis. **A,** Occluded aortoceliac/SMA Dacron graft with blood supply from collateral sources. **B,** After careful dissection through overlying scar, transaortic endarterectomy is performed with trapdoor aortotomy. Old graft is removed with patch angioplasty to repair distal anastomotic sites.

nique used at the original procedure was endarterectomy (n = 7), antegrade bypass was used in six patients (85.7%). The techniques most often used for visceral reoperation are illustrated in Figs. 1 and 2.

At second reoperation one patient underwent transaortic endarterectomy of the celiac artery, which had not previously undergone operation. Otherwise, at all other secondary or tertiary reoperations, antegrade bypass (n = 4) was preferred, but other techniques (retrograde bypass, thrombectomy and anastomotic revision, IMA graft repair; n = 3) were also used.

The IMA underwent revascularization during 13 reoperations. IMA revascularization accompanied antegrade bypass grafting or transaortic endarterectomy of the celiac artery, SMA, or both in eight reoperations. In five reoperations the IMA was the only visceral artery that underwent revascularization. Transaortic endarterectomy of the IMA was performed in seven cases. Other techniques including bypass grafting and reimplantation were used in the remaining six cases.

Perioperative mortality data and complications. Two patients (6.7%) died in the perioperative period after the 30 visceral reoperations, both after first reoperation. One patient died of bowel infarction on the first postoperative day after undergoing revision of an occluded aortoceliac prosthetic graft. The other patient had acute visceral ischemia after reoperative transaortic endarterectomy of the celiac artery, SMA, and IMA and ultimately died of sepsis and multiple organ failure after a prolonged intensive care unit course.

Significant morbidity was noted among 10 of the 30 patients who underwent visceral reoperation (33.3%). Complications included dissection and thrombosis of an IMA endarterectomy requiring reoperation, sepsis (n = 2), bleeding requiring reoperation (n = 2), intraabdominal abscess, pancreatitis, splenic laceration requiring splenectomy, prolonged ileus, lower extremity deep venous thrombosis, and respiratory failure requiring reintubation.

Follow-up. Follow-up from visceral reoperation averaged 80 months and ranged from 1.5 to 188 months. One patient was found to have an asymptomatic occlusion of her repair on routine postoperative angiography and underwent a second reoperation during the same hospitalization. Symptoms of visceral ischemia recurred in six (27.3%) of 22 patients 2 weeks to 24 months after first visceral reoperation. Three of the six patients underwent a second reoperation and subsequently had no symptoms or had significant improvement. One of the six patients underwent two additional reoperations, after which she had no symptoms. Two patients with recurrent visceral ischemic symptoms did not undergo further revascularization. Arteriography showed occlusion of an SMA bypass but a widely patent IMA endarterectomy in one patient who was monitored conservatively. Her postprandial pain resolved,

and she had no symptoms 7 years later. The other patient had no symptoms for 24 months after reoperation when acute abdominal pain developed. He died despite extensive resection of ischemic bowel. Overall, the cumulative symptom-free survival rate was 77.3% at 1 year and 62.8% at 5 years after visceral reoperation.

Two patients were referred after undergoing multiple visceral operations at other institutions. One patient underwent her second and third reoperations at UCSF. After her third reoperation she had no symptoms and died of lung cancer 6 years later. The other patient was referred after three visceral operations and underwent a third reoperation with antegrade bypass grafting to the celiac artery and SMA and transaortic endarterectomy of the IMA. Seven months later she had recurrent symptoms resulting from occlusion of the SMA bypass, which was successfully managed by percutaneous transluminal angioplasty and urokinase infusion. She has required two additional percutaneous interventions and has no symptoms nearly 10 years later.

Survival data by life table analysis of the 90 patients with nonrecurrence who underwent primary visceral revascularization only at UCSF and of the 24 patients who underwent visceral reoperation is displayed in Fig. 3. The cumulative survival rate at 5 years after primary visceral revascularization was 61.9% and at 5 years after visceral reoperation was 74.6%.

Factors associated with recurrent visceral ischemia. To identify clinical variables associated with the development of recurrent visceral ischemia, the 90 patients who underwent primary visceral revascularization and did not have recurrent visceral ischemia were compared with the 19 patients who underwent primary visceral revascularization at UCSF and later had recurrent visceral ischemia (acute or chronic). At the time of initial presentation patients who later had recurrent ischemia lost significantly more weight (35.1 ± 19.3 pounds vs 22.5 ± 16.4 pounds; $p = 0.009$) and tended to be younger (57.7 ± 12.0 vs 63.1 ± 10.6 years; $p = 0.05$) than patients who did not have recurrent ischemia. Factors such as sex, tobacco use, and diabetes mellitus did not differ between the groups.

When factors at the initial operation were compared, no difference was found between the groups with respect to the frequency of celiac, SMA, or IMA repairs, the operative technique (antegrade bypass, transaortic endarterectomy, or other), the surgeon performing the operation, or the incidence

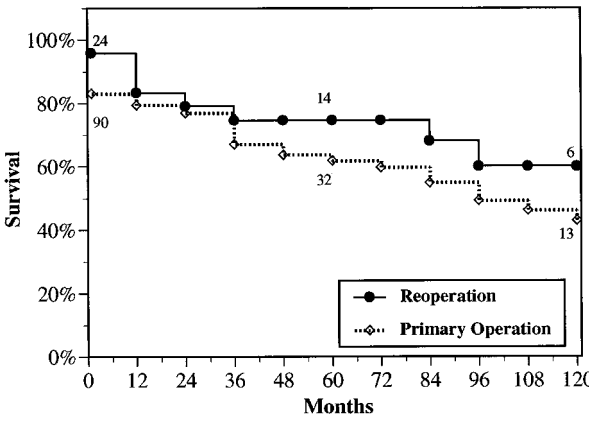

Fig. 3. Life table analysis of postoperative survival after primary visceral revascularization for chronic visceral ischemia (n = 90) or reoperation for recurrent chronic visceral ischemia (n = 24). For reoperation patients' survival is calculated from date of first reoperative procedure performed at UCSF. Number of patients available for follow-up at 60 and 120 months is indicated. Standard error is less than 10% at all points.

of postoperative complications. The only factor associated with failure of primary visceral revascularization was intraoperative modification of the intended revascularization procedure as specified by the surgeon in the operative note. By this criteria the primary operative technique was modified in 36.8% of operations in the recurrent group and in 12.2% of operations in the nonrecurrent group ($p = 0.02$). Although no significant difference was found between the UCSF recurrent and nonrecurrent groups in the number of visceral arteries that underwent revascularization at primary operation ($p > 0.5$), when all 24 patients who underwent reoperation (including referral patients) were compared with the nonrecurrent group, the difference became significant. The mean number of vessels that underwent revascularization at original operation was significantly less in the 24 patients who underwent reoperation (1.5 ± 0.5) than in the nonrecurrent group (1.9 ± 0.6; $p = 0.004$).

DISCUSSION

It is well established that operative visceral revascularization can effectively correct chronic visceral ischemia. Yet despite the overall success most series have reported late failures. Zelenock et al.[7] reported an overall failure rate of 34% in their series of 23 patients, most of whom underwent visceral artery bypass grafting procedures. Hollier et al.[6] reported an overall late recurrence rate of 27%, which was

inversely correlated with the number of visceral arteries that underwent revascularization. More recently, Johnston et al.[16] reported graft thrombosis in 14% of 21 patients who underwent elective visceral artery bypass grafting. McMillan et al.[3] used duplex ultrasonography to assess the patency of visceral artery grafts and reported a 3-year graft failure rate of 11%.

Our cumulative experience with the surgical management of chronic visceral ischemia confirms that recurrent ischemia is not uncommon. Recurrence was documented in 17.4% out of 109 patients who underwent primary visceral revascularizations at UCSF. Patients who had recurrent visceral ischemia fell into two distinct categories with strikingly different outcomes. One third of patients had recurrent acute visceral ischemia, and 85.7% of these patients died of bowel infarction. Recurrent acute ischemia was uniformly fatal in the perioperative period, in agreement with previous reports.[5-7,17] In contrast, two-thirds of the patients with recurrent visceral ischemia had symptoms of chronic visceral ischemia. When compared with patients with recurrent acute ischemia, patients with recurrent chronic visceral ischemia had better outcomes. Rapid recognition of the symptoms of chronic visceral ischemia and revascularization before the development of bowel infarction apparently contributed to the improved outcome in this group of patients.

Additional improvement in outcome after visceral revascularization might be realized by identifying patients who are at increased risk for recurrent visceral ischemia. We found that patients who later went on to have recurrent intestinal ischemia lost more weight before their primary visceral revascularization procedure compared with patients in our series who did not have recurrent ischemia (Table IV). There also appeared to be an association between recurrent visceral ischemia and younger age at primary visceral revascularization. Other groups have also observed the development of acute visceral ischemia in younger patients after primary visceral revascularization.[7,17] This finding may indicate that a subgroup of patients has a more aggressive disease process that initially presents at an earlier age and is apt to recur sooner. In addition, premature atherosclerosis is thought to be associated with hypercoaguability,[18-20] which was documented in two of our patients with recurrent acute visceral ischemia and aortovisceral graft thrombosis.

Controversy currently exists regarding the number and priority of visceral vessels that should undergo revascularization at primary operation. Hollier et al.[6] suggested that the frequency of recurrent visceral ischemia was inversely related to the number of visceral vessels that underwent revascularization and reported recurrence rates of up to 50% when only one artery underwent revascularization. Many investigators promote revascularization of at least the celiac artery and SMA at primary operation on the basis of similar observations.[16,21,22] However, this view has been challenged by reports from other groups that describe low mortality and recurrence rates after isolated bypass grafting to the SMA.[23,24] Our preferred approach is to perform revascularization on both the celiac artery and SMA, which may explain why we were unable to detect a difference in the number of vessels repaired at primary operation between the UCSF recurrent and UCSF nonrecurrent groups. When we compared all patients with recurrence including patients who underwent primary operations elsewhere with the nonrecurrent group, the number of visceral arteries that underwent revascularization at the primary operation was significantly lower in the recurrent group. Although these results suggest that complete revascularization at primary operation may prevent recurrent visceral ischemia, the differences in outcome must be interpreted with caution. The observed difference could be the result of factors other than the number of vessels that underwent revascularization, because the primary operations were performed by different surgeons at multiple hospitals.

Most of the patients in this series underwent visceral reoperation with the same techniques that we routinely use for primary visceral revascularization.[2] Antegrade aortovisceral bypass grafting or transaortic thromboendarterectomy was performed in 20 (90.9%) of the 22 first reoperations. Selection of the revascularization technique was based on the technique used for previous revascularization. Typically, antegrade bypass grafting was used to repair a previously endarterectomized artery and, conversely, endarterectomy was often used to manage a failed bypass graft (antegrade or retrograde). Combinations of these two techniques were used in the remaining two first (9.1%) reoperations. Scarring caused by multiple operations or previous end–to–end anastomosis to major visceral arteries precluded the use of endarterectomy in all but one of the eight second or third reoperations. Aortovisceral bypass grafting or local revision of a previous repair was performed in these cases. Occasionally revascularization of the IMA alone was successful when revascularization could not be performed in

other major visceral arteries. In most of the cases we found that the same operative techniques used for primary visceral revascularization could be applied to convert a failed repair to a successful revascularization. Moreover, transaortic visceral endarterectomy was safely and effectively used in the reoperative setting.

In-hospital deaths occurred after 6.7% of the 30 reoperations for chronic visceral ischemia and were caused by graft failure resulting in bowel necrosis. Complications were observed in one third of patients. Although such mortality and complication rates are not trivial, they are comparable with results reported after primary visceral revascularization.[2–6,21,22,24,25] It is interesting that the incidence of complications was not less in patients who underwent visceral reoperation in more recent times and may reflect an increased frequency of comorbid conditions in this group of patients.

With a mean follow-up of 80 months the cumulative symptom–free survival rate at 5 years was 62.8% in patients who underwent reoperation compared with 86.1% in patients who underwent primary visceral revascularization at UCSF.[2] Despite the slightly higher rate of recurrence after visceral reoperation, most patients eventually had improvement after an additional reoperation. After reoperation for recurrent chronic visceral ischemia was performed, the long-term survival rate was 74.6% compared with 61.9% after primary visceral revascularization. Thus our long-term results with secondary visceral revascularization approach those achieved with primary visceral revascularization.[2-6,21,22,24,25]

Given the likelihood that without revascularization most patients with chronic visceral ischemia symptoms will progress to fatal visceral infarction[26] and the favorable outcome after repeat visceral revascularization, it would be ideal to identify patients with failing grafts before they have symptoms of visceral ischemia. Mesenteric duplex scanning can accurately assess visceral vessels after endarterectomy or bypass grafting and may allow the detection of asymptomatic stenoses, allowing elective reoperation before visceral ischemia develops.[3,27] We now routinely monitor patients who undergo visceral revascularization with mesenteric duplex scanning after operation. When recurrence is detected by duplex scanning or suggested by the reappearance of symptoms, biplanar aortography is obtained to facilitate planning for the secondary visceral revascularization.

CONCLUSION

On the basis of our experience with the surgical management of recurrent chronic visceral ischemia, we conclude that recurrent visceral ischemia after primary visceral revascularization is not uncommon. Although recurrent acute visceral ischemia is associated with a high mortality rate because of bowel infarction, patients with recurrent chronic visceral ischemia may be successfully treated with repeat visceral revascularization. The established techniques of transaortic visceral endarterectomy and aortovisceral bypass grafting can both be used in the reoperative setting, and the selection of either technique should be based on the type of previous revascularization used. Because the incidence of recurrent visceral ischemia may be influenced by the completeness of primary visceral revascularization, we recommend revascularization of both the celiac and the SMA. Finally, additional studies are required to determine whether routine duplex scanning after visceral revascularization can identify asymptomatic recurrent visceral ischemia and improve long-term survival rates.

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DISCUSSION

Dr. Gerald B. Zelenock (Ann Arbor, Mich.). I would like to offer my congratulations to Dr. Schneider and the San Francisco group for their excellent, well-written, and well-presented article and my thanks for the opportunity to discuss this work. This topic is important for several reasons. Their report of 33 patients with recurrent visceral ischemia, including 24 with chronic recurrent visceral ischemia, forms the largest review of this particular problem to date. Their carefully studied patient population provides some reasonable practice guidelines for us all.

It is important to note that mesenteric vascular disease causing visceral ischemia remains a persistent problem in clinical practice and is often underappreciated and distressingly slow to be recognized or considered even when multiple diagnostic studies have been undertaken and do not identify an underlying cause of the patient's symptoms. In our experience at Michigan, 6 to 7 months of diagnostic studies have often been undertaken before the patient is referred for evaluation often with an acute or a subacute abdominal crisis. This is certainly true in the initial presentation of patients with mesenteric vascular disease and appears also to be somewhat of a factor in the patients with recurrent disease.

Dr. Schneider's report also outlines the enormous differences between acute recurrent visceral ischemia and chronic recurrent visceral ischemia. The latter has a quite reasonable mortality rate of 6.7%, and this is a particularly excellent result given the complexity of secondary and tertiary reconstructions. However, acute recurrent visceral ischemia has a mortality rate of fully 86% even in the hands of these very experienced surgeons and underscores the need for promptly making a diagnosis and undertaking therapy.

The authors carefully point out the need for a thorough grounding in all of the various techniques of visceral revascularization. Their experience emphasizes the need for familiarity with the multiple approaches and techniques, because no one technique is appropriate or usable in all circumstances. The article also highlights the importance of persistence. Twenty-seven percent of their patients undergoing a first reoperation had recurrent symptoms, half of which were cured by a third or a fourth operation. Their overall results were exceptional for

patients with chronic recurrent visceral ischemia with a life-table survival rate of 75% at 5 years and symptom-free survival of 77% and 63% at 1 and 5 years. I have only two questions for the authors.

Do you have information regarding the interval from onset of symptoms to diagnosis and definitive therapy for your patients with recurrent visceral ischemia, and how does that compare with the same interval in your 109 patients with primary visceral revascularization? And two, given your recognition of hypercoagulable states, particularly in the younger patients, are they now recommending routine postoperative anticoagulation in these patients?

Again, my congratulations to the San Francisco group for their excellent results and their clear and well-presented report.

Dr. Darren B. Schneider. Thank you for your kind comments, Dr. Zelenock. With regard to your first question about the interval from the onset of symptoms to the diagnosis of primary visceral ischemia, I agree with what you have said. Patients with primary visceral ischemia tended to have a delay from the development of symptoms to diagnosis and reoperation of approximately 12 months. In contrast, probably because of their history of a visceral revascularization, patients with recurrent visceral ischemia were given diagnoses much earlier. Their interval to diagnosis of recurrent ischemia averaged 3 months, and in many cases it was much shorter.

With regard to whether patients with acute visceral ischemia should undergo routine anticoagulation, I do not believe that has been determined. It is interesting that two of the seven patients with acute recurrence of their visceral ischemia did have hypercoagulable syndromes. Because this was a retrospective review, I do not know what the actual incidence of hypercoagulable conditions was. More than one half of the patients with acute recurrence were in their 40s, and they may belong to a subpopulation of patients with premature atherosclerosis associated with hypercoagulability. It is possible that this subgroup of patients would benefit from anticoagulation.

Dr. Kenneth J. Cherry Jr. (Rochester, Minn.). I would like to congratulate Dr. Schneider for an excellent article and excellent presentation. Dr. Schneider, I have a few questions for you if I could.

In retrospect, do you have any idea how many patients had asymptomatic reconstructive failures? You may well not, because I know many of these predated the advent of duplex surveillance scanning. Also, in retrospect, are any of the patients who had acute exacerbations, or were any of those patients? I know they did not have any formal reconstructions. Could they have had, was there a window of opportunity there in which they might have had a formal reconstruction?

The next question is, were you able to determine the cause of the failure? Was it an anastomotic problem, or was it progression of atherosclerosis in the recipient vessels? We have seen that in a number of patients actually with patent grafts but extension of their atherosclerosis. And although you report that the results are comparable, there is a 27% failure rate within 2 years. And I am making the assumption it is because the reconstruction had to be carried to a much more distal site on the main mesenteric vessels, or indeed to branches, and I wondered whether that were the case.

Dr. Schneider. Thank you, Dr. Cherry. With regard to your first question about asymptomatic occlusions, we do not have any data on this subject because many of the operations were before the introduction of mesenteric duplex scanning. The study by McMillan from the Northwestern group has clearly shown that grafts may be objectively followed with mesenteric duplex scanning. Currently, we are following our patients with mesenteric duplex scanning.

Regarding recurrent acute visceral ischemia and whether these patients may be revascularized, in our experience these patients usually presented with bowel infarction. None of the seven patients underwent a formal revascularization. Thrombectomy was attempted but was unsuccessful in two patients. The lone surviving patient had a patent visceral revascularization but an isolated segment of jejunum that was infarcted and was resected.

It is true that 27% of our patients had recurrence after visceral reoperation. This may reflect a selection bias because patients with recurrent visceral ischemia may have a more aggressive type of atherosclerosis.

I do not know the cause of recurrence in all our cases. We suspect that many early recurrences are the result of technical failures, whereas late recurrences appear to be caused by progressive atherosclerotic disease.

Dr. Walter J. McCarthy III (Chicago, Ill.). I rise to congratulate the authors on their presentation today and also for their innovative leadership in this area over the last 3 decades. Our experience at Northwestern also advocates a comprehensive revascularization for patients with chronic ischemia, for which we preferentially use saphenous vein grafts to both the SMA and the celiac and sometimes to the inferior mesenteric arteries. Recently we reviewed this cohort and found that the patency of these grafts was 89% with a 6-year follow-up. We detected, with a duplex surveillance program, several patients who had one graft that had occluded but the other one was still patent, keeping them asymptomatic. None of those patients has presented with bowel ischemia in the surveillance period. I just have two questions for the authors.

Can you speculate from your follow-up on recurrence rates comparing endarterectomy and bypass graft revascu-

larization? Second, can you tell us who the younger patients are, and why do you think they are recurring early?

Dr. Schneider. Thank you for your comments, Dr. McCarthy. It is difficult to determine whether recurrence was more frequent after endarterectomy or bypass because many of the patients underwent their original operations at other hospitals. Most of the patients referred underwent visceral bypass at their primary operation. Among the UCSF group there were similar numbers of patients who originally underwent endarterectomy or bypass. Several of these patients underwent operations that are no longer used at UCSF including transarterial endarterectomy and bypass with saphenous vein. Currently, our preferred conduit is Dacron, but we have not found a significant association between the choice of conduit and recurrence.

Patients with acute ischemia were younger, and it is possible that this is because they have a more aggressive variant of atherosclerosis. Other conditions such as hypercoagulability may also contribute to recurrence by causing thrombosis of visceral repairs. This appeared to be the case with two of our patients who presented with recurrent acute visceral ischemia.

Dr. Robert B. Smith III (Atlanta, Ga.). I think we all admire the San Francisco group for their breadth of experience in this area. It is interesting that their recurrences were diagnosed, on the whole, more promptly than the original illness. We, in fact, have had patients at Emory perceptive enough to come back and report that "I have the same condition again." Of course, that eliminates some of the diagnostic studies. I have two questions.

The first relates to the management of the occluded graft. Have you had experience with urokinase, with or without balloon angioplasty, as a way to try to reopen the graft short of a big operation? You have shown excellent morbidity and mortality on your elective reoperations, but there is no question that it is a sizable undertaking.

The second question is an inference from some of the things we have heard about asymptomatic occlusions. The admonition in the literature is to perform multiple revascularizations on the first occasion so that if one fails, the other will maintain the patient. One would infer then that it is okay to accept one graft failure as long as the patient has no symptoms. Would that be your interpretation as well, or would you feel that a failed superior mesenteric artery graft puts the patient at greater risk and should be addressed?

Dr. Schneider. Dr. Smith, with regard to your first question, one patient in our series underwent three visceral reoperations and later presented with occlusion of a bypass graft to the SMA. She was successfully treated with angioplasty and urokinase infusion. She has had two additional angioplasties and has no symptoms 10 years after her third visceral reoperation. Based on this limited experience, angioplasty and urokinase may be a viable alternative in selected cases.

In terms of accepting failure of one graft as long as the other remains patent, that is the idea behind revascularizing both major visceral vessels. Of course, we prefer that all grafts remain patent. When a graft fails, I do not know whether it is more important that the celiac or the SMA remains patent. Although there is greater blood flow through the SMA, we have been successful in revascularizing only the celiac artery in several patients when that was all that was possible.